OUTBREAKS OF THE BLACK FLY *SIMULIUM ARCTICUM* MALLOCH IN ALBERTA*

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The subgenus Gnus *Rubzov is represented in Alberta by at least four species. One of these,* Simulium arcticum *Mall., is the only species of black fly known to kill large farm animals in the province. It is widely distributed, the immature stages occurring in most or all streams and rivers originating on the slopes of the Rocky Mountains and other elevated areas such as the Swan Hills. Outbreaks that have killed animals are known from only two areas. Near Minburn, east of Edmonton, a few cattle were killed and people suffered serious effects from bites in June of 1956 and in late May of 1961. Near Athabasca, north of Edmonton, outbreaks occur throughout a period of several weeks every summer, disrupting grazing and breeding activities and reducing production of milk and beef. A few cattle were killed there in 1955 or 1956, and in June of 1963 and 1964.*

Although bulls are most affected, no farm animals are exempt from attack. Initial attacks are usually so sudden and violent that animals are damaged before they can be taken indoors. Humans are relatively immune to attack but when bitten sometimes require medical attention or even hospitalization.

Other species of the subgenus Gnus *known to occur in Alberta are* S. corbis *Twinn and* S. malyshevi *D. R. and V. in west-central and northern areas and* S. defoliarti *S. and P. in the extreme south-west.* S. nigricoxum *S. is not known outside of the Northwest Territories and Alaska. Damaging outbreaks of* S. defoliarti *occur in south-central British Columbia but not in Alberta.*

DISTRIBUTION OF *S. ARCTICUM* IN ALBERTA

Simulium arcticum Malloch is widely distributed in Alberta (Table 1 and Fig. 1). In addition to the records in Table 1, Hearle (1932) reported that *S. arcticum* was abundant in the Athabasca River at Jasper (no date), Strickland (1938) listed it as occurring on July 19 in the Jasper area (possibly Hearle's collection) and Abdelnur (1968) reported on some aspects of its life history and habits in the Pembina and Athabasca Rivers at Flatbush.

Although larvae and pupae were encountered throughout the entire collecting season (mid-May to early September) the period of greatest abundance on the plains was June 5 to 15, and in the mountains, early July. Future surveys in greater detail will undoubtedly prove that these periods of peak abundance vary from year to year. In Saskatchewan the immature stages have been collected in almost every month of the year although the species normally overwinters as eggs (Fredeen *et al.*, 1951) and larvae and pupae attain greatest abundance between mid-May and mid-June each year.

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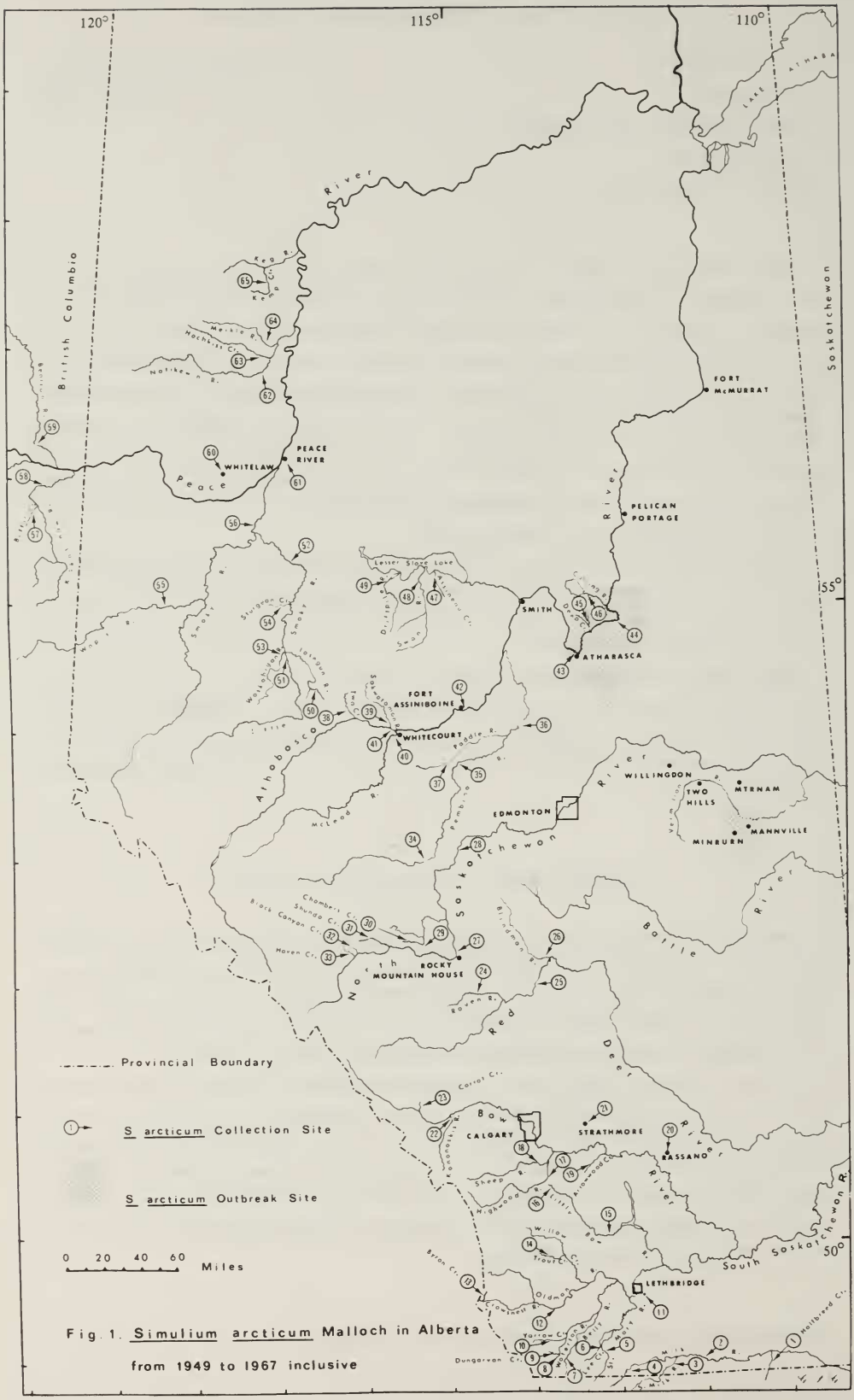

Fig. 1. Simulium arcticum Malloch in Alberta from 1949 to 1967 inclusive

TABLE 1. Streams and rivers in Alberta and the Peace River District in British Columbia, from which the immature stages of *Simulium arcticum* Mall. were collected.

Site*	Location	Date	Abundance	Stages of Development**
1	Half Breed Creek, Aden	August 9, 1953	Scarce	L, P.
2	Milk River, Milk River	August 27, 1952	Scarce	L, P.
3	South Milk River, Del Bonita	August 27, 1952	Scarce	L, P.
4	North Milk River, Whiskey Gap	August 27, 1952	Scarce	L, P.
5	St. Mary River, Cardston	August 28, 1952	Scarce	L, P.
		August 10, 1953		
		July 12, 1958		
		September 4, 1958		
6	Lee Creek	August 10, 1953	Scarce	L, P.
7	Belly River, Mountain View	August 28, 1952	Moderate	L, P.
		August 10, 1953		
8	Waterton River, Waterton	August 28, 1952	Moderate	L, P.
9	Dungarvan Creek, Twin Butte	August 10, 1953	Moderate	L, P.
		May 16, 1961		
10	Yarrow Creek, Twin Butte	August 28, 1952	Moderate	L, P.
		August 10, 1953		
11	Irrigation canal, Lethbridge	August 11, 1954	Scarce	L, P.
12	Oldman River, Brocket	August 28, 1952	Scarce	L, P.
13	Byron Creek, Crowsnest	August 8, 1954	Scarce	L, P.
14	Trout Creek, Claresholm	May 15, 1961	Scarce	L, P.

TABLE 1 (continued)

Site*	Location	Date	Abundance	Stages of development**
15	Little Bow River, Carmangay	May 17, 1961	Moderate	L, P. (30% emerged)
16	Little Bow River, High River	August 29, 1952	Scarce	L, P.
17	Highwood River, High River	August 8, 1954	Scarce	L, P.
18	Sheep River, Okotoks	August 29, 1952	Scarce	L, P.
19	Arrowwood Creek, Mossleigh	May 17, 1961	Scarce	L, P. (emergence not begun)
20	Irrigation Canal, Bassano	August 7, 1954	Scarce	L, P.
21	Irrigation Canal, Strathmore	June 18, 1958	Scarce	L, P.
22	Kananaskis River, Seebe	September 8, 1947	Moderate	L, P.
23	Carrot Creek, Duthill	August 31, 1951	Scarce	L, P.
24	Raven River, Caroline	May 28, 1950	Moderate	L, P.
25	Red Deer River, Penhold	June 11, 1949	Scarce	L, P. (emergence beginning)
25	Red Deer River, Penhold	August 30, 1952	Scarce	L, P.
26	Blindman River, Burbank	June 1, 1950	Moderate	L, P. (emergence beginning)
27	N. Saskatchewan R., Rocky Mt. House	June 12, 1949	Abundant	L, P. (2% emerged)
27	N. Saskatchewan R., Rocky Mt. House	September 3, 1952	Scarce	L, P.
28	N. Saskatchewan R., Drayton Valley	July 18, 1961	Scarce	L.
29	Small rill, Horburg	June 10, 1963	Scarce	L, P.
30	Chambers Creek, Horburg	June 10, 1963	Abundant	L, P. (Emergence beginning)
31	Shunda Creek, Nordegg	June 10, 1963	Abundant	L, P.
31	Shunda Creek, Nordegg	July 4, 1963	Scarce	L, P.
32	Black Canyon Creek, Nordegg	June 10, 1963	Scarce	L, P.
		July 4, 1963		

TABLE 1 (continued)

Site*	Location	Date	Abundance	Stages of development**
33	Haven Creek, Nordegg	July 4, 1963	Abundant	L, P. (emergence beginning)
34	Pembina River, Lodgepole	July 11, 1961	Absent	Other species abundant
35	Pembina River, Sangudo	July 11, 1961	Absent	Other species abundant
36	Pembina River, Westlock	July 14, 1961	Scarce	Other species abundant
37	Paddle River, Rochfort	July 11, 1961	Scarce	L, P.
		June 5, 1963		
38	Two Creeks, Windfall	June 5, 1963	Scarce	L, P. (emergence beginning)
38	Two Creeks, Windfall	June 10, 1963	Scarce	L, P. (90% emerged)
39	Sakwatamau River, Whitecourt	June 5, 1963	Abundant	L, P. (emergence beginning)
40	McLeod River, Whitecourt	July 12, 1961	Absent	
40	McLeod River, Whitecourt	June 5, 1963	Abundant	L, P. (about 50% emerged)
40	McLeod River, Whitecourt	July 14, 1964	Scarce	L, P.
41	Athabasca River, Whitecourt	July 14, 1964	Scarce	L.
41	Athabasca River, Whitecourt	July 14, 1964	Moderate	L, P.
42	Athabasca River, Fort Assiniboine	July 14, 1964	Moderate	L, P. (18% emerged)
43	Athabasca River, Athabasca	June 9, 1963	Scarce	P. (empty)
44	Athabasca River, Athabasca	August 3, 1967	Scarce	Adults floating on river surface
45	Deep Creek, Athabasca	June 17, 1966	Scarce	P.
45	Deep Creek, Athabasca	May 30, 1967	Moderate	L.
46	Calling River, Athabasca	August 4, 1967	Scarce	L.
47	Assineau Creek, Wagner	June 9, 1963	Scarce	L, P. (emergence beginning)

TABLE 1 (continued)

Site*	Location	Date	Abundance	Stages of development**
48	Swan River, Kinuso	June 9, 1963	Scarce	L, P. (emergence beginning)
49	Driftpile River, Joussard	June 9, 1963	Scarce	L, P.
50	Iosegun River, Fox Creek	June 10, 1963	Abundant	L, P.
51	Little Smoky River, Fox Creek	June 5, 1963	Abundant	L, P. (emergence beginning)
52	Little Smoky River, Donnelly	June 10, 1963	Moderate	P.
53	Waskahigan River, Little Smoky	June 5, 1963	Abundant	L, P. (about 50% emerged)
		June 10, 1963		
54	Sturgeon Creek, Valleyview	June 5, 1961	Scarce	P. (all empty)
55	Wapiti River, Grande Prairie	June 9, 1961	Scarce	L, P.
56	Smoky River, Watino	June 21, 1961	Moderate	L.
57	Buffalo Creek, Dawson Creek, B. C.	June 6, 1963	Scarce	L, P. (emergence beginning)
58	Kiskatinaw River, Dawson Creek, B. C.	June 15, 1961	Abundant	L, P. (5% emerged)
59	Beaton River, Cecil Lake, B. C.	June 16, 1961	Scarce	P.
60	Whitelaw, Alberta	July 21, 1964	Scarce	Adults only
61	Peace River, Alberta	July 21, 1964	Scarce	Adults only
62	Notikewin River, Manning	June 7, 1963	Scarce	P. (all empty)
63	Hotchkiss River, Manning	June 7, 1963	Scarce	L, P. (emergence beginning)
64	Meikle River, Manning	June 7, 1963	Scarce	P. (emergence beginning)
65	Kemp Creek, Keg River	June 11, 1963	Scarce	L, P.

* See Figure 1

**L = larvae, P = pupae

The subgenus *Gnus* (Rubzov, 1940) to which *S. arcticum* belongs is holarctic. *S. arcticum,* however, is restricted to western North America, occurring throughout the mountainous regions from Alaska south to California. Specimens have been collected as far east as Churchill, Manitoba (Twinn *et al.*, 1948). In Saskatchewan, farm animals have been killed in numerous outbreaks originating in the Saskatchewan River system (Cameron, 1922; Rempel and Arnason, 1947; Fredeen, 1958). The most destructive series of outbreaks in Saskatchewan occurred 1944 to 1947 inclusive when more than 1100 animals were killed. Some aspects of the life cycle of this black fly other than these outbreaks are described by Fredeen (1958, 1963), Fredeen *et al.* (1951) and Abdelnur (1968). In Alberta, livestock has been killed in at least five outbreaks (Table 2).

The immature stages of three other species of the subgenus *Gnus* were also collected in Alberta and northern British Columbia but these species have never been implicated in damaging outbreaks in Alberta. Specimens of *S. corbis* Twinn were obtained from a few streams and rivers in northern areas and the west-central foothills as follows:

Assineau Creek at Canyon Creek (July 3, 1950, May 31 and June 23, 1961); Fawcett River, Smith (May 31, 1961); Sucker Creek, High Prairie (May 31, 1961); Sweeney Creek, 10 miles S.W. of Clear Prairie (June 16, 1961); Clear Creek, Clear Prairie (June 16, 1961); Wagner Creek, Widewater (June 23, 1961); Sakwatamau River, Whitecourt (June 5, 1963); Ksituan River, Gordondale (June 7, 1963); Chambers Creek and Shunda Creek, Horburg (June 7, 1963); Haven Creek, Nordegg (July 4, 1963); Kiskatinaw River, Dawson Creek, B. C. (June 15, 1961); Buffalo Creek, Progress, B. C. (June 6, 1963).

S. defoliarti was collected only in the foothills in the S. W. corner of the province:

Belly River, W. of Mountain View (August 28, 1962; August 10, 1953); Highwood River, W. of Longview (August 8, 1954); Castle River, W. of Pincher Creek (May 7, 1955); Crowsnest River, N. of Lundbreck (May 7, 1955).

In the Shuswap River in south-central British Columbia this species breeds in such large numbers that chemical control of the larvae is occasionally required. Severe outbreaks in 1951 affected gains in beef animals, causing losses in excess of 24,000 dollars (Curtis, 1954). However, in Alberta it is not known to occur in nuisance numbers. *S. malyshevi* D. R. and V. was collected as follows:

Clearwater River, Waterways (June 18, 1948); E. Prairie River, Enilda (June 3, 1961); Goose Creek, Calais (June 6, 1961); Beaton River, Cecil Lake, B. C. (June 16, 1961).

A fifth species of the subgenus *Gnus, S. nigricoxum* S. may also occur in the north end of the province as it is widely distributed in the Northwest Territories and Alaska.

Samples of the immature stages of these black fly species were obtained by wading into the margins of rapids to pick up rocks and tree branches by hand. Equipment has not yet been devised that will allow the river bed to be quantitatively sampled in deep, fast-flowing rapids. Since the levels of mountain-fed rivers are relatively unstable, even at distances of 1000 miles or more from their sources, and since the margins of these rivers advance and retreat irregularly according to rates of snow melt and precipitation in the watersheds, our marginal samples served only to indicate the presence or absence of *S. arcticum*. Seldom were water levels low enough to allow examination of infestations of larvae and pupae in the relatively permanent mid-river sites. However, on June 5, 1963, low levels on the McLeod River at Whitecourt and the Waskahigan and Little Smoky Rivers at Little Smoky, exposed dense infestations of larvae and pupae, approximately similar to those sometimes seen in both branches of the Saskatchewan River in Saskatchewan prior to damaging outbreaks. Moderately dense infestations were discovered in several other large rivers including the

TABLE 2. Damaging black fly outbreaks in Alberta attributed to *Simulium arcticum* Mall.

Source	Area affected: Location	Area affected: Approximate size (sq miles)	Dates of outbreaks	Damage
N. Saskatchewan River	Minburn, etc.	900	1956, second week of June	A few cattle killed, milk production reduced, many people injured, two requiring hospital treatment
N. Saskatchewan River	Minburn, etc.	900	1951, last week of May	A few cattle killed, milk and beef production reduced, some people injured
N. Saskatchewan River	Minburn, etc.	900	1962, May 22 to 25	A mild outbreak, milk cows bothered for a few days
Athabasca River	Grassland, Boyle, etc.	1000	1955 or 1956	A few cattle killed, general productivity of livestock reduced
Athabasca River	Grassland, Boyle, etc.	1000	1963, mid-June to mid-July	Several animals killed including two bulls and four calves, several bulls became sterile, others improved after treatment, production of milk and beef declined noticeably, people and livestock occasionally forced indoors
Athabasca River	Grassland, Boyle, etc.	1000	1964, May 30 to Sept. (worst on June 10-16)	At least one bull killed and two others sterilized; production of milk and beef declined; people, cattle, sheep and horses occasionally forced indoors
Athabasca River	Grassland, Boyle, etc.	1000	1965, June 7 to 24	Livestock severely bothered on June 24
Athabasca River	Grassland, Boyle, etc.	1000	1966, June 24 to Aug. 27 (worst on July 2 to 21 and Aug. 26, 27)	No fatalities but grazing and breeding of livestock affected, beef and milk production noticeably declined, men and cattle were occasionally driven indoors, a few people required medical attention
Athabasca River	Grassland, Boyle, etc.	1000	1967, June 5 to Sept. 28 (worst on June 19 to July 25 and on Sept. 17)	Effects similar to those observed in 1966

North Saskatchewan River at Rocky Mountain House on June 12, 1949 and the Athabasca at Fort Assiniboine on July 14, 1964. Eight per cent of the *S. arcticum* larvae in the Athabasca River in mid-July of 1964 were parasitized with mermithid nematodes, but nowhere else were these parasites observed.

SOME CHARACTERISTICS OF THE NORTH SASKATCHEWAN AND ATHABASCA RIVERS

These two rivers and their major tributaries flow in vegetation-free beds consisting mainly of boulders, gravel and clean sand. The growth of vegetation is effectively prevented by the eroding effect of the ice during the spring breakup and by frequent flood crests during the summer.

In the upper reaches, gradients are relatively steep and boulders and gravel predominate; on the plains the gradient is flatter, often averaging only about one foot per mile, and here the river bed consists mainly of sand. In some regions of the plains, however, the gradients are much steeper than this and the rivers flow in series of rapids over gravel and boulders. These boulders provide favoured attachment sites for enormous numbers of *S. arcticum* larvae and pupae. An outstanding example is a rock-filled weir across the North Saskatchewan River at Prince Albert, Saskatchewan which on June 9 and 10, 1947 was estimated to contain more than 7×10^9 pupae (Fredeen, 1958).

On the North Saskatchewan River in Alberta there are rapids north of Willingdon and Myrnam, north to north-west of the outbreak area near Minburn (Fig. 1). On the Athabasca River there are numerous rapids between Whitecourt and Smith, a few scattered rapids from Smith down to about the Pelican Portage Settlement and very numerous rapids and falls downriver from there to Fort McMurray. This latter section of the river has an average gradient of about 5.4 feet per mile and, although it was not sampled during these investigations, was considered likely to be a major breeding site for *S. arcticum*. It is 65 miles and more, directly north of the center of the annual outbreak area in the county of Athabasca.

The average ice-free period in these two rivers lasts from 6.5 to 7.0 months (Table 3). Ice breakup in the spring generally begins when the river level rises sharply as a result of melting snow on the plains and foothills. Following this crest the level generally subsides irregularly until a new major crest occurs in late June or early July as a result of rapid thawing and precipitation in the mountains. Maximum volume discharges ranging up to about 200,000 cu feet/sec have been recorded on both rivers and minimum discharges of less than 2000 cu feet/sec generally occur in the winter.

Water temperatures during the summer in these two rivers are likely to be a few degrees lower than those on the North Saskatchewan at Prince Albert in Saskatchewan where maxima of 70 to 75°F are attained in July and August. There the larvae and pupae of *S. arcticum* attain greatest abundance in May and June when water temperatures range from 45 to 65°F.

Water turbidity increases with increases in the water level. Values greater than 3000 ppm have been measured on the South Saskatchewan River. This turbidity has been used to advantage during black-fly larviciding (Fredeen *et al.*, 1953).

TABLE 3. Some characteristics of the North Saskatchewan River at Edmonton, Alberta. and the Athabasca River at Athabasca, Alberta. (Canada Department of Energy, Mines and Resources, 1967).

	North Saskatchewan River	Athabasca River
Drainage area (sq. miles)	10,500	29,600
Average annual discharge (ft^3/sec)	7,660 (54 years)	15,100 (30 years)
Maximum discharge (ft^3/sec)	204,500 (June 28, 1915)	199,600 (June 10, 1954)
Minimum discharge (ft^3/sec)	220 (Jan. 1, 1940)	1,610 (December 14, 1956)
Average ice-free period (months)	7.0 (April 13 to Nov. 10)	6.5 (April 21 to November 8)

SOME FACTORS INVOLVED IN THE DEVELOPMENT OF DAMAGING OUTBREAKS

Rempel and Arnason (1947) suggested that the appearance of a massive swarm of *S. arcticum* was due simply to mass emergence plus fortuitous winds. Additionally there is recent evidence that the first ovarian cycle may be completed autogenously; in some instances at least, the females do not attack animals for blood until after the eggs from the first ovarian cycle have been laid (Fredeen, 1963). This means that emerging females can accumulate, perhaps throughout a period of several days, awaiting weather conditions suitable for oviposition. This could result in the release of enormous numbers of blood-thirsty black flies within a period of a very few hours. Perhaps both factors have been responsible in the development of damaging outbreaks.

Winds play a very important part in the distribution of adult black flies. Variable-direction winds will scatter them over a wide sector, thinly enough that they will obtain their blood meals unnoticed. However, livestock owners should be wary when the wind blows steadily from proven breeding grounds for even a few hours. In one Saskatchewan outbreak, livestock was killed 140 miles downwind from such a breeding site. In a few other instances an abrupt shift in the wind direction has been known to transfer black flies from one area into another, with resultant fatalities in both (Rempel and Arnason, 1947).

The appearance of large numbers of black flies in a district is generally sudden and furthermore often occurs in the early morning or late evening so that a severe attack can begin before livestock owners are aware of their presence. Also, reactions to massive injections of the toxin are swift, and the animals can become fatally ill within a few hours after the black flies commence their attack.

The nature of the toxin is poorly known. Hutcheon and Chivers-Wilson (1953) showed that the salivary extract contained an anticoagulant and a substance that gave reactions similar to those from histamine. A detailed account of symptoms in cattle is given by Millar and Rempel (1944) who investigated an outbreak of *S. arcticum* in the Macdowall area in Saskatchewan. They reported that residents in the district noticed the appearance of black flies in the district on the evening of May 30 but did not consider them to be unusually abundant until the following morning. Animals subjected to heavy attack throughout May 31 developed fluid-filled swellings along the underlines. Some additionally developed a heavy, jerky breathing accompanied by a strong trembling of the muscles. Animals with such symptoms either died within 15 minutes to two hours, or made a complete recovery within 48 hours. Deaths were attributed to acute toxemia but anaphylactic shock was not ruled out.

TYPES OF LOSSES TO BE EXPECTED DURING OUTBREAKS OF *S. ARCTICUM*

Fatalities

The numbers of fatalities in livestock that have occurred in Alberta as a result of black fly outbreaks are small when compared with losses during the large outbreaks in Saskatchewan in the 1940s. However, about half of the losses were those of herd sires (generally the most expensive animals in the herds). Mature bulls are often more attractive to blood-sucking flies than are cows or calves. Furthermore, imported bulls show less resistance to attack and damage than do native bulls, especially those allowed to spend most of their time out-of-doors. However, whether imported or native, at the first signs of an outbreak the herd sires require special attention and should be stabled or at least kept under close observation.

Some veterinarians were reluctant to agree that these livestock fatalities in Alberta resulted from black fly attacks. Although I did not personally observe any of the fatalities, I agree with the conclusions reached by the owners, none of whom were preconditioned in their thinking by being aware of similar occurrences in Saskatchewan.

Suspension of breeding activities

During black fly outbreaks, breeding activities are interrupted when the cattle become involved in protective activities, i.e. seeking shelter in buildings, dense brush and sloughs. This suspension of breeding activities results in an irregular and delayed calf crop the following year, thus decreasing net returns from the enterprise. Also, individuals of *S. arcticum* normally attack along the underline of an animal and the bull's sheath thus becomes in-

flamed and may develop secondary infections requiring treatment by a veterinarian. Some bulls remain permanently sterile despite treatment.

Declines in the production of milk and beef

These phenomena are frequently observed by livestock owners but losses are difficult to measure. These losses naturally occur when normal pasture grazing is interrupted and physical activities are increased. Additionally, however, a milking cow's udder is a favourite target for black flies and this makes extraction of milk a more difficult process, either for the nursing calf or for man. Reports from owners such as "black flies drove cattle out of the pasture", "black flies kept cattle in shed all day", "cows' udders red with blood", "cows difficult to milk because of black flies", "milk production down something terrible", are commonplace during outbreaks.

General losses resulting from repeated threats of outbreaks

A loss that is seldom recognized in an area subjected to frequent, severe black fly outbreaks is the general shift from livestock to alternate farm enterprises. In the Athabasca region of Alberta livestock enterprises should predominate to ensure the healthiest economic development of the region because of the relatively short frost-free season, the rough terrain with much marginal land suitable only for pasture and forage crops, and soils that require crop rotations for best productivity. However, some residents have either reduced or eliminated their livestock enterprises and certain highly skilled breeders have even emigrated to other districts where they will not be threatened by black flies. These shifts do not seem to be warranted in terms of measurable losses that have occurred but rather can be attributed to the general suspense created by unpredictable and uncontrolled outbreaks.

The moderate numbers of black flies that occur almost daily during the summer can be tolerated by men and animals without too much discomfort. However, increases in the numbers of black flies can generally be expected whenever the wind blows steadily for a few hours from breeding grounds in the river and occasional outbreaks have also occurred when the wind has blown from some direction other than the river (Fig. 2). Since winds often shift during the night, and black fly flight activity is generally greatest in early morning and late evening hours, many severe outbreaks have begun with surprising suddenness. Sometimes the first indication of an outbreak has been the stampede of cattle from pasture to barn. Less fortunate operators have their livestock scatter into the brush where they are less likely to be protected. Thus a strong element of suspense prevails throughout the outbreak season.

Effects on man

Although people can generally protect themselves with repellents, there are occasional days in the County of Athabasca when people are driven indoors along with their cattle to escape savage attacks. Normally individuals of *S. arcticum* do not attack man but when attacks occur, medical attention may be required to alleviate severe swelling and itching of the affected limbs.

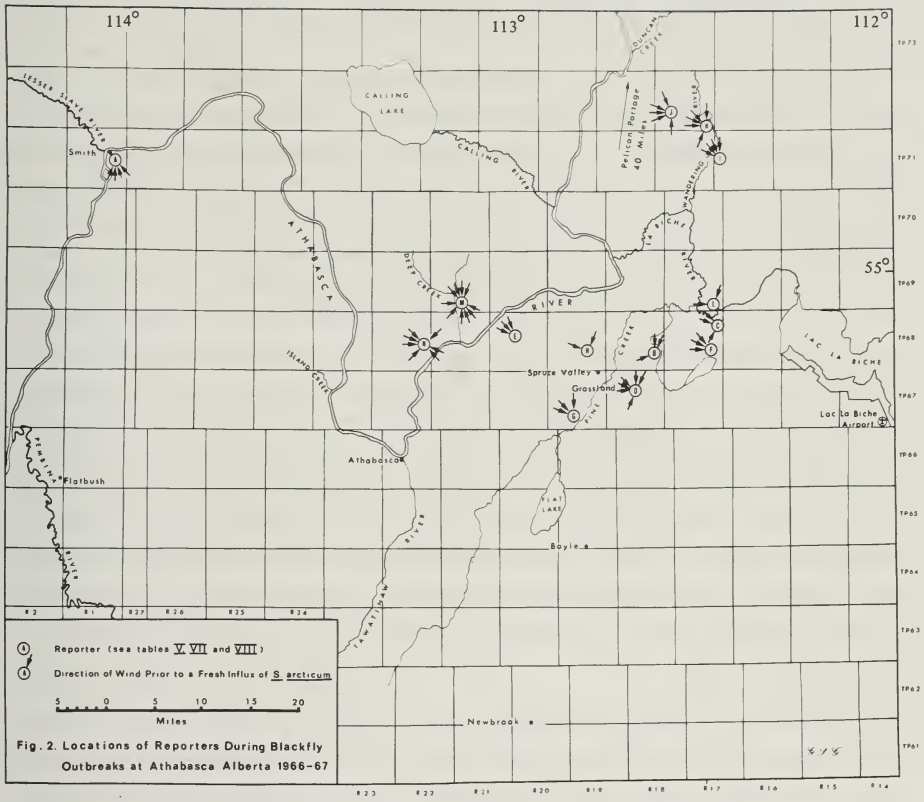

Fig. 2. Locations of Reporters During Blackfly Outbreaks at Athabasca Alberta 1966–67

DESCRIPTIONS OF OUTBREAKS OF *S. ARCTICUM* IN ALBERTA

Outbreaks adjacent to the North Saskatchewan River

A black fly outbreak in the Municipal District of Minburn No. 72 was investigated on July 9 and 10, 1961 at the request of Mr. J. B. Gurba, Supervisor of Crop Protection and Pest Control for the Alberta Department of Agriculture. The outbreak had actually occurred during the third week in May but was of such short duration that by the time the black flies had been identified as *S. arcticum* conditions had already returned to normal. Thus the purpose of my visit in July was to determine the extent and severity of the outbreak by interviewing livestock owners. The following were interviewed at a Municipal Council meeting and others on their farms: Mr. C. Gamble, a local livestock feeder and Field Supervisor for the Municipal District, Mr. Ed. McLaughlin, farming about 6 miles N. W. of Mannville, Mr. A. W. Roland, about 5 miles S. of Minburn and Mr. G. Grabos, ½ mile S. of Innisfree. They stated that black flies were pests of mammals, especially milking cows, every year for a few days around the third week in May. Outbreaks were reported to have been especially severe in dry years, the worst outbreaks having occurred in 1956 and 1961 when an area of

about 900 square miles centering on Mannville was affected (Fig. 1). During each of these two outbreaks a few cattle were reported to have been killed and the udders of milk cows were red with blood. Among others, Mr. McMillan farming east of Mannville lost cattle during the 1956 outbreak.

Perhaps the most serious aspect of these two outbreaks was the requirement by many people for medical attention as a result of complications following black fly bites. This has also been a common feature of *S. arcticum* outbreaks in Saskatchewan. Dr. Hasinoff of the Municipal Hospital at Minburn informed me that he had treated many people for black fly bites in 1956. They had come from an area 30 to 40 miles in diameter surrounding Mannville and Minburn. Black flies collected while attacking people were all *S. arcticum*.

Two men in particular had had such severe reactions in 1956 that they required long medical attention and one of these, a Mr. S., was still unwell in 1961. The following symptoms, and the results of clinical tests in Edmonton, led Dr. Hasinoff to believe that Mr. S. exhibited a distinct case of Arthus' syndrome (Brown *et al.*, 1938) or localized anaphylactic reactions following sensitization by injections of black fly toxins. Dr. Hasinoff stated that Mr. S. reported to him on June 10, 1956 in respiratory distress, itchy and with evidence of black fly bites. Later he developed ulcers down to the bone on limbs that had not been bitten. These were not due to infection but could only be ascribed to allergic reactions to the black fly toxins. Mr. S. spent 5 months in the hospital before the ulcers finally healed. Gudgel and Grauer (1954) and others have described severe reactions in humans that necessitated medical treatment at the actual locations of black fly bites, but this may be the first case where reactions have been observed in areas of the body remote from locations where the bites occurred.

In 1962, May 22 to 25, another outbreak of *S. arcticum* occurred in the Mannville area but this was of moderate intensity. By the time we received word of it and visited the area on May 26 to 30 the outbreak had ended. However, specimens collected from barn windows were all *S. arcticum*. On May 26, only a few adults could be collected around cattle and these were a mixture of *S. arcticum* and *S. venustum* Say. The weather became cool and wet about this time and individuals of these two species disappeared. Near Two Hills and Myrnam a few specimens of *Cnephia saskatchewana* S. and F. were collected flying around cattle but none were actually seen on the cattle.

Since 1962 no further reports of black fly outbreaks have been received from this district. On May 22, 1963 only a few *S. venustum* and *S. vittatum* Zett. were found around cattle.

These outbreaks of *S. arcticum* all occurred following northerly winds and thus the extensive rapids on the North Saskatchewan River at several sites north of Willingdon and Myrnam may have been the sources (Fig. 1). I have never examined these rapids for larvae or pupae because of high water levels at the times I was in the area. However, on several occasions I found abundant *S. arcticum* larvae in the North Saskatchewan River or its tributaries above Edmonton (Table 1) and also at several sites in the province of Saskatchewan. Individuals of this species have never been collected from the Vermilion or Battle Rivers despite several thorough searches. On the other hand species such as *S. venustum* breed in these smaller rivers but not in the Saskatchewan River. Experience has shown that individuals of *S. venustum* can be annoying to animals and man living within a half mile of their

breeding places but not far beyond that distance. Individuals of *S. arcticum* are known to have a much longer flight range and thus when animals have been killed or damaged several miles from the nearest potential breeding site, *S. arcticum* rather than *S. venustum* has always been the culprit.

The possibility should not be overlooked that the Athabasca River rather than the Saskatchewan may have been the source of the black flies in the outbreaks in the Minburn area. This would have required flights of about 150 miles, but in one outbreak of *S. arcticum* in Saskatchewan, livestock were killed by black flies that had been carried by the wind more than 140 miles from their point of origin (Fredeen, 1958). Two separate sources however are suggested by the differences in the seasons of the outbreaks, those at Minburn occurring between late May and early June, and those at Athabasca between late May and July and occasionally August or September.

In the North Saskatchewan above Edmonton, *S. arcticum* larvae and pupae are sometimes abundant but severe outbreaks have never been reported from that area. A farmer near Rocky Mountain House reported in 1949 that black flies were common and troublesome throughout June, July and August every year. He had also observed swellings under the jaws of horses during the black fly seasons and reported that a disease locally called "swamp fever" used to kill many horses. Horses newly brought into the area were said to have been particularly susceptible to swamp fever. The symptoms included swellings under the belly, bleeding from the mouth and nostrils and rapid mortalities. These symptoms suggest black fly damage but for the fact that fatalities in cattle did not occur according to the reporter.

Outbreaks adjacent to the Athabasca River

Residents in the County of Athabasca report that since the earliest years of settlement, annual outbreaks of "sand flies" or black flies have occurred. They were believed to originate in the large swampy areas near the Athabasca and La Biche Rivers. Although they make their first appearance during northerly winds in late May or in June and often persist into September, the swarms doing the greatest damage are always expected in late June or early July.

Livestock has been killed apparently only in three years, 1955 (or 1956), 1963 and 1964. However, every year livestock productivity is affected to some degree. These outbreaks were regarded as uncontrollable events until 1963, following establishment of a County Agricultural Service Board. When an unusually severe outbreak occurred in 1963, the County Agricultural Fieldman, Mr. H. Armfelt, recognized the problem as one that required immediate attention. He obtained the assistance of Mr. J. B. Gurba and on July 12 they surveyed the outbreak area and obtained the following information (Gurba, 1963). The "sand flies" had appeared suddenly that year after the first warm period in June. Arriving on northerly winds they caused greatest damage in an area measuring about 20 miles north and south by 5 miles east and west, centered on Grassland and Spruce Valley. Scattered instances of attack occurred as far south as Boyle and Newbrook. Two bulls and four calves were killed by the black flies about June 15 and many other animals became ill, some requiring a veterinarian's attention. Livestock and people new to the area were most severely affected. Insecticide sprays and smudges gave some relief to milking cows but in general

milk and beef production declined noticeably during June and July. Black flies collected from cattle on July 12 were all *S. arcticum*. As a result of this outbreak I was asked to help locate breeding areas and recommend control measures.

In July of 1964 a careful examination of the Athabasca River between Whitecourt and Smith proved the existence of numerous rapids well populated with *S. arcticum* larvae and pupae. Unfortunately a sudden rise in the water level prevented examination of rapids below Smith at that time.

Also in July of 1964, a number of livestock owners in the eastern half of the County of Athabasca were interviewed and their reports showed that another extensive outbreak had occurred. Black flies had been first seen around cattle on May 30 after an all-day wind from the north. However, June 10 was the first day that the cattle were noticeably irritated by the black flies. On June 16 a new influx of black flies on a north wind forced man and livestock alike to remain indoors and killed at least one bull. This appearance of the first damaging swarms of the year during the first warm weather in mid-June was said to be typical. For about three weeks in 1964 these attacks continued to affect normal grazing and breeding activities, milk production and weight gains.

Black flies collected alive from cattle and horses in many localities in the County on July 18 and 19, 1964 were 92% *S. arcticum*, 6% *S. venustum* and 2% *S. vittatum*. Although these black flies were moderately abundant around cattle, the latter were grazing normally in the pastures. Collections of dead flies from the windows of a barn six miles northwest of Grassland, presumably trapped during the spring outbreak of 1964, contained 99% *S. arcticum* and 1% *S. venustum*. Thus although *S. arcticum* seemed to be the main species involved in the outbreaks of 1964, precise information as to the relative importance of it and other local species throughout all spring and summer outbreaks was still lacking. This information was obtained in two ways: by a widespread survey for the immature stages in streams and rivers in and near the County in 1964, 1966 and 1967, and by collecting adults from widespread attacking swarms throughout the entire outbreak seasons of 1966 and 1967.

The area in and around the County of Athabasca is traversed by many small streams, a few small rivers such as the La Biche and Wandering Rivers, and one large river, the Athabasca (Fig. 2). Early in these investigations it was thought that *S. venustum*, especially from the La Biche and Wandering Rivers, might have been at least partly responsible for the severe outbreaks in nearby farmlands almost directly south of these rivers. The survey of rivers and streams showed that *S. venustum* was actually widespread, but abundant in only two streams, Pine Creek (May 31, 1967) and Wandering River (May 18 and June 7, 1966, and May 31, 1967) (Table 4). Other species whose immature stages were also widespread included *S. verecundum* S. and J. (a close relative of *S. venustum* although apparently nonbiting (Stone and Jamnback, 1955)), *S. vittatum* and *S. tuberosum* (Lund.). Individuals of *S. vittatum* are large and grey, commonly seen in the ears of livestock, but are not usually considered to be serious pests. They were occasionally abundant in the La Biche River, Calling River and Pine Creek. *S. tuberosum*, although widespread, was never abundant. *S. arcticum* was abundant only in the Athabasca River. Insignificant numbers were found breeding in Calling River and Deep Creek but these sources were too small to have contributed significantly to the outbreaks.

TABLE 4. Species of black fly larvae and pupae found in rivers and streams in Athabasca County and its environs, 1964 to 1967 inclusive

Species	Collection data
Prosimulium gibsoni (Twinn)	Duncan Creek, May 17, 1966
Simulium arcticum Mall.	Athabasca River (Whitecourt to Smith) (moderate numbers) July 14, 1964; Deep Creek, rare, June 17, 1966 and May 30, 1967; Calling River, rare, August 4, 1967
S. aureum Fries	La Biche River, July 19, 1964
S. croxtoni N. and M.	Island Creek, June 15, 1966
S. decorum Walker	Tawatinaw River, July 16, 1964; Flat Creek, June 20, 1967; Pine Creek, June 14, 1967; Babiak Creek, June 20, 1967
S. furculatum (Shewell)	Deep Creek, June 15, 1966
S. latipes (Meigen)	Pine Creek, June 14, 1966; Creek S. E. 27-68-20, June 16, 1966; Wandering River, June 7, 1966
S. luggeri N. and M.	Pembina River, July 15, 1964
S. meridionale Riley	Pembina River, July 15, 1964; Lesser Slave River, July 20, 1964
S. rugglesi N. and M.	Pembina River, July 15, 1964
S. tuberosum (Lund.)	Widespread but scarce, May to July inclusive
S. venustum Say	Widespread, May to August inclusive; abundant in Pine Creek, May 31, 1967; Wandering River, May 18 and June 7, 1966, May 31, 1967
S. verecundum S. and J.	Widespread, June and July; abundant in Bear Creek and Deer Creek, June 16, 1966
S. vittatum Zett.	Widespread, May to October inclusive; abundant in La Biche River, July 19, 1964 and May 17, 1966, Calling River, July 18, 1964 and Pine Creek, July 21, 1966

Altogether the immature stages of 14 species were discovered. Of these, *S. arcticum*, because of the immensity of its breeding site, was considered to have the greatest potential for developing large, damaging swarms.

Despite these extensive collections of the immature stages, decisive evidence as to the actual species involved in the outbreaks was obtained only with the co-operation of 14 residents, situated in and near the County (Table 5, Fig. 2) who netted more than 46,000 black flies from swarms attacking their livestock in 1966 and 1967 (Table 6). At some of the sites black flies were netted every three days or so (oftener during outbreaks), throughout much of the spring and summer flight periods; at other sites, collections were taken only during prominent outbreaks.

In 1966, *S. arcticum* represented 92.2% of all black flies netted and in 1967, 89.6%. *S. venustum* appeared in moderate abundance on only one occasion, May 31, 1967, (site no. 14, Fig. 2) and *S. vittatum* on one occasion, September 17, 1967 (site no. 9, Fig. 2). At all

TABLE 5. Collectors and observers of black fly activity in and near the County of Athabasca in 1966 and 1967.

Reference symbol (See map, Fig. 2)	Years of observations 1966	1967	Name	Direction of winds required to bring black flies from major breeding sites on the Athabasca River
A		x	Earl, J.	S. and E.
B	x		Davidiuk, J.	N. and N. W.
C		x	Fischer, Mrs. J.	N. and N. W.
D	x	x	Guy, M.	N. and N. W.
E	x	x	Kamelchuk, J.	N. and N. W.
F	x	x	Semashkewich, J.	N. and N. W.
G	x	x	Whitney, J.	N. and N. W.
H	x	x	Zelinski, N.	N. and N. W.
I *	x	x	Coonan, B. and L.	N., N. W. and W.
J *		x	Mitchell, M.	N., N. W. and W.
K *	x	x	Rabkavich, P.	N., N. W. and W.
L *	x		Steed, L.	N., N. W. and W.
M	x	x	Klak, W.	N., E. and S. E.
N	x	x	Shalapay, D.	N., E. and S. E.

*These sites are north of the La Biche River but, except for L, are located near the Wandering River.

TABLE 6. Species of black flies collected from swarms near farm animals, in and near the County of Athabasca*, Alberta, 1966 and 1967

	1966		1967		
Total no. collected	12,764		33,603		
	% of total	No. of times collected	% of total	No. of times collected	Sources of collections**
S. arcticum Mall.	92.2	70	89.6	92	Cattle, hogs, horses, sheep
S. decorum Walk.	0.1	6	0.9	18	Cattle, horses
S. furculatum (S.)	< 0.1	1	0.0	0	Farmyard
S. latipes (M.)	0.0	0	> 0.1	1	Cattle
S. meridionale Riley	< 0.1	2	0.0	0	Cattle
S. pugetense (D. & S.)	< 0.1	2	0.0	0	Farmyard
S. tuberosum (L.)	< 0.1	3	0.5	20	Cattle, hogs
S. venustum Say and *S. verecundum* S. & J.	4.5	33	2.3	58	Cattle, hogs, horses, sheep
S. vittatum Zett.	3.1	52	6.7	63	Cattle, hogs, horses, sheep

* See Fig. 2 for locations of the collection sites.

** Some of the *S. arcticum* were collected from barn windows after detaching from livestock that had carried them into the buildings.

other times only relatively small numbers representing species other than *S. arcticum* were collected (Table 6). Thus it seems certain that the several severe and sometimes damaging outbreaks in 1966 and 1967 were caused by individuals of *S. arcticum*, only.

Although the immense numbers of *S. arcticum* observed could only have had their origin in a large river, i.e. the Athabasca, additional evidence as to the sources of these outbreaks was obtained by relating the times of the outbreaks as reported by the co-operators, to hourly wind data obtained from the Canada Department of Transport Meteorological Station at the Lac La Biche Airport located 29 miles east and four south of Grassland P. O. These data are listed in Tables 7 and 8. Almost invariably, each fresh invasion of black flies, as indicated by a distinct increase in the severity of attack, was found to have been preceded by winds blowing from some section of the Athabasca River (Fig. 2). On a few occasions, however, the wind had been blowing from some other direction, or had been virtually calm. Perhaps some of these anomalies were due to the fact that the wind and black fly data came from sites separated by 30 miles or more. However, individuals of *S. arcticum* have been observed to move upwind for short distances during outbreaks in Saskatchewan. In one instance they seemingly moved 1.5 miles against a wind strong enough to raise dust from the

TABLE 7. Wind conditions prior to outbreaks of *S. arcticum* Mall. in and near the County of Athabasca, Alberta, in 1966

Data from observers									
Time of report and/or collection						Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations		Net wind vector**	
Day		Hour	Observer*	Report	No. of *S. arcticum* collected			Direction	Total miles
June	24	1900 (est)	H	From cattle	1		8	NW	28
June	25	1900 (est)	D & F	From cattle	2		8	W	82
June	26	1900 (est)	F	From cattle	8		0	(winds light, ESE)	
June	28	1900 (est)	F	From cattle	6		0	(winds SE)	
June	30	1900 (est)	B	From cattle	22		2	WSW	13
July	1	1900 (est)	F	From cattle	19		13	WNW	46
July	2	0930	B	Extremely bad in morning	340	0	The black flies	(calm in AM,	
July	2	1120	D	Air black with flies	473	0	apparently	then light, easterly)	
July	2	0830	F	Solid cloud around cattle	1470	0	entered the		
July	2	1000	G	First big outbreak	30	0	area on the		
July	2	0600	H	First big outbreak; came early in AM	91	0	westerly winds		
July	2	1100	I	From cattle and barn window	206	0	of July 1		
July	3	1900 (est)	M	From cattle	330		39	ESE	296
July	3	1900 (est)	N	From cattle	21		39	ESE	296
July	4	1920	F	Many around cattle	84		4	WNW	10
July	5	1975	F	Many around cattle; girl bitten	269		7	NW	45
July	5	1500	G	Flies quite bad	0		2	N	19

TABLE 7. (continued)

Time of report and/or collection			Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day		Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
July	6	1900 (est)	B	From cattle	6	5	W	47
July	7	1600	M	From cattle	103	13	SW	59
July	7	1600	N	From cattle	11	13	SW	59
July	8	0830	E	Many around cattle, making them nervous	9	1	SW	8
July	9	1900	F	From cattle	622	8	W	67
July	9	1900 (est)	L	From cattle	6	8	W	67
July	10	1830	B	Very bad today	47	3	N	4
July	10	1900 (est)	N	From cattle	1	11	W	19
July	11	0815	D	Lots of flies	243	15	WNW	87
July	11	0930	E	Many around cattle	43	17	WNW	105
July	11	1900 (est)	M	From cattle	232	0	(NW wind)	
July	12	0830	F	From cattle	128	36	NW	216
July	12	1900 (est)	K	From cattle	19	0	(wind light, SE)	
July	13	1900 (est)	M	From cattle	55	39	SE	103
July	14	1900 (est)	E	From cattle	49	0	(wind light, E)	
July	14	1900 (est)	G	From cattle	1	0	(wind light, E)	
July	15	1900	B	From cattle	112	0	(wind light, SE, NE)	

TABLE 7. (continued)

Time of report and/or collection			Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day		Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
July	15	1900	H	Many in evenings of July 15 and 16	247	0	(wind light, SE, NE)	
July	16	1930	D	Flies pretty thick	256	4	NNE	14
July	16	1900 (est)	K	From cattle	23	3	NE	11
July	16	1900 (est)	M	From cattle	411	9	ESE	16
July	17	1900 (est)	E	From cattle	49	28	WNW	125
July	17	2030	F	From cattle in barn	480	29	WNW	125
July	17	1900 (est)	N	From cattle	1	0	(wind light, NW)	
July	18	1800	F	Collected near barn	53	0	(calm)	
July	20	1900 (est)	B	From cattle	17	22	WNW	122
July	20	0700	E	Lots of flies in morning	63	11	NNW	40
July	21	2030	D	Bad attack on cattle today	314	47	WNW	428
July	21	1915	F	Collected from cattle near barn	58	46	WNW	428
July	23	1900 (est)	E	From cattle	54	7	W	70
July	23	1900	F	From cattle near barn	74	7	W	70
July	24	1900	H	Many, although none earlier today	158	19	NNE	75
July	24	1900 (est)	H	From cattle	1	19	NNE	75
July	26	1900 (est)	E	From cattle	28	19	NW	37

TABLE 7. (continued)

Time of report and/or collection			Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day		Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
July	26	1900 (est)	F	From cattle	9	19	NW	37
July	28	1500	F	From cattle	10	14	W	89
July	29	1900	E	From cattle	27	13	W	146
July	30	1700	B	From cattle	10	4	W	13
Aug.	1	0800	E	Many around cattle	86	0	(7 hour calm in AM)	
Aug.	1	1900 (est)	F		1	0	(7 hour calm in AM)	
Aug.	4	1200	E	From cattle	15	11	WNW	26
Aug.	8	1900 (est)	E	From cattle	30	0	(winds SSE)	
Aug.	12	1900 (est)	E	From cattle	32	19	WNW	123
Aug.	26	1900 (est)	B	From cattle	216	18	NNE	45
Aug.	26	0800	I	From cattle	2648	24	WNW	33
Aug.	27	0800	I	From cattle	922	48	N	127

* See map (Fig. 2) for locations of observers.

**Wind data were obtained from the Canada Department of Transport, Meteorological Branch Station at Lac La Biche Airport, Alberta.

TABLE 8. Wind conditions prior to outbreaks of *S. arcticum* Mall. in and near the County of Athabasca, Alberta, in 1967

Time of report and/or collection		Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day	Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
June 5	1730	I	A few flying, others on cattle	1	17	NNW	93
June 15	1800	K		2	0	(calm)	
June 19	1930	C	Black cloud around animals	527	42	WNW	225
June 19	1600	D	Black flies came all at once	164	38	WNW	231
June 19	0930	J	Not too many up until now	13	32	WNW	88
June 20	1800	D	Very bad around sheep	268	65	WNW	325
June 20	0900	E	First appearance of large numbers	47	56	WNW	252
June 20	1000	G	Flies worst yet; not really bad though	1	57	WNW	259
June 20	1900	K		39	66	NW	341
June 20	2100	M	Flies chased cows out of pasture	47	5	N	38
June 20	1100	N	From milk cows	70	58	WNW	269
June 21	0900	M	Cows would not stay in pasture	63	17	NNE	77
June 22	2100	C	Flies very bad since June 18	1888	115	NW	518
June 22	0730	D	Yard was full of black flies	385	102	NW	435
June 22	1600	D	Flies came by the millions	262	110	NW	496
June 23	1200	E	Many flies, mostly around noon	42	130	NW	514

TABLE 8. (continued)

Time of report and/or collection		Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day	Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
June 23	1830	G	Flies moderately bad	2	137	NW	504
June 23	2030	I	Flies thicker in late afternoon	632	139	NW	504
June 23	0900	J	From cattle in yard	29	127	NW	510
June 23	0900	M	Hordes of flies in barnyard	48	127	NW	510
June 23	1100	N	Bad on cows' udders	42	129	NW	510
June 24	1830	F	From cattle in yard	1	0	(virtually calm)	
June 24	0900	M	From barn window	93	26	W	30
June 25	1830	A	Today is the heaviest infestation	46	15	SSW	38
June 25	2010	C	Milk production down something terrible	137	0	(light S. winds)	
June 25	1800	D	Flies on cattle in pasture	34	0	(light S. winds)	
June 25	1000	G	Flies not bad; cattle resting easily	8	0	(light S. winds)	
June 25	1830	K	Flies very bad	37	10	SSW	32
June 26	2000	D	Black flies everywhere	300	13	NW	41
June 26	1100	E	Lots feeding on hogs and cattle	116	4	W	20
June 26	1000	J	On cattle	190	5	WSW	17
June 27	0800	F	By cattle	55	25	WNW	45

TABLE 8. (continued)

Time of report and/or collection		Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day	Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
June 27	0930	G	Worst yet but not bad	4	27	WNW	58
June 29	2015	C	Feeding only; not as many as on 26, 27, 28	875	19	W	259
June 29	1700	E	Not many sandflies	15	16	W	232
June 29	1530	J	Infestation less heavy than normal	750	15	W	222
June 30	1930	D	Black flies kept cattle in shed today	890	24	W	299
July 1	1900	D	Air black with flies; they kept sheep in shed	571	11	N	64
July 1	0930	G	Not many flies	20	38	WNW	375
July 1	1700	I	Flies very thick; many feeding	2048	9	NNW	67
July 1	1830	K	Flies very bad	1495	11	N	65
July 1	0900	M	From barn window	71	6	WNW	48
July 1	2000	N	Flies around cattle	22	7	NE	44
July 2	0630	A	Heaviest infestation; flies mainly feeding	46	8	NNW	37
July 2	2030	C	Worst yet; flies in clouds	1160	14	SSW	36
July 2	2000	D	Millions; cows stayed in barn all day	393	13	SSW	36
July 2	1730	E	Flying around hogs	114	11	NNW	42
July 3	0745	J	Around cows in yard	248	25	S	52

TABLE 8. (continued)

Time of report and/or collection		Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day	Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
July 3	2100	M	On barn windows	75	56	SSE	175
July 6	0730	E	Lot of sand flies around cattle	404	0	(light S. winds)	
July 6	1630	G	Flies pretty bad around horse	3	2	NW	9
July 6	1500	I	Very many flies; mostly feeding	932	0	(light SE winds)	
July 6	1100	J	From cows in yard	387	0	(light SE winds)	
July 8	0630	A	Not too thick but bothering cattle some	65	7	S	8
July 8	0900	F	Quite mean to cattle this morning	662	4	WNW	4
July 8	1130	N	From cows in yard	840	3	NE	10
July 9	2000	D	From cows in yard	826	25	WNW	195
July 9	1800	F	From cows in yard	473	23	WNW	184
July 10	2030	C	Clouds of black flies; most this year	1520	50	WNW	478
July 10	2000	H	From barn window	163	49	WNW	469
July 10	1400	J	From cow in yard	1635	43	WNW	419
July 11	0700	A	From cattle in yard	62	0	(calm)	
July 11	0730	E	Lots of sand flies around cattle	404	61	WNW	440
July 11	1030	M	From barn window	50	5	ENE	11

TABLE 8. (continued)

Time of report and/or collection		Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day	Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
July 11	1000	N	From cattle in yard	268	5	NE	7
July 13	0630	A	Quite a few on cattle	95	7	SE	70
July 13	0930	F	Around cattle in yard	198	0	(from SE)	
July 13	0800	N	Around cattle in yard	509	52	SE	382
July 14	0800	F	Around cattle in yard	6	16	W	113
July 14	1930	F	Very many; seem to be meaner than usual	497	28	W	287
July 14	1330	J	Around cattle in yard	765	22	W	202
July 15	1830	K	Flies very bad	264	51	W	226
July 15	1000	N	Around cattle in yard	349	10	W	28
July 16	0900	E	Very many all day	249	0	(winds light from SE)	
July 17	0600	A	Flies worst when air is calm	71	7	SE	42
July 17	0830	N	Around cattle in yard	374	57	SE	164
July 18	0830	F	Flies have been quite bad last few days	844	9	NW	27
July 18	0900	M	Flies from barn window	59	0	(light N winds)	
July 19	1815	A	From cattle in yard	80	1	SSE	5
July 19	0800	E	Many flying and feeding	192	6	N	5

TABLE 8. (continued)

Time of report and/or collection			Data from observers			Number of hours that the wind** had been blowing from the Athabasca River immediately prior to the observations	Net wind vector**	
Day		Hour	Observer*	Report	No. of *S. arcticum* collected		Direction	Total miles
July	19	1700	J	Around cattle in yard	83	3	WNW	6
July	19	0900	N	Around cattle in yard	543	1	ESE	5
July	23	2015	C	Flies quite bad	434	39	W	208
July	23	0900	E	Many sandflies; cattle kicking	370	28	WNW	168
July	23	0900	F	From cattle in yard	76	28	WNW	168
July	25	1700	D	Air black with black flies	338	4	W	37
July	27	1430	J	From cattle in yard	187	4	NNW	25
Aug.	13	1830	J	From cattle in yard	308	40	W	266
Aug.	16	1700	D	Not many black flies	73	0	(from NE)	
Sept.	17	1000	I	Around cattle in yard	184	22	SSW	31
Sept.	18	0900	M	From barn window	34	19	S	22
Sept.	28	1800	K		14	12	WNW	133

* See map (Fig. 2) for locations of observers

**Wind data were obtained from the Canada Department of Transport, Meteorological Branch Station at Lac La Biche Airport, Alberta.

fields. The livestock they attacked was pastured near the edge of a wooded valley connected to the Saskatchewan River Valley and the black flies presumably made most of their upwind approach in the shelter of the valley walls and trees.

The annual outbreaks in the County of Athabasca are of unusual duration. Outbreaks at Minburn and in the Province of Saskatchewan last for only a few days whereas at Athabasca they often last for three or four weeks. For instance, in 1966 an outbreak began with typical violent suddenness on July 2 and continued with slowly declining severity until August 1. Remissions occurred mainly on those days when the wind was blowing towards the river rather than from it. An apparent second outbreak in 1966, lasting only two days, occurred in late August (Table 7). (Similar autumn outbreaks have occurred in Saskatchewan).

In 1967 the annual outbreak began suddenly on June 19 and continued with only a few brief remissions until at least July 25. Again there was a distinctly separate autumn outbreak, this time on September 17 and 18, but the outbreak was sufficiently mild that it was observed at only two sites.

Abdelnur (1968) recorded four apparent cycles of *S. arcticum* larval abundance in the Athabasca River in 1965, with peaks in late May, early July, early August and mid-September. However, his data, based on direct counts of larvae, presumably obtained by wading into shallow marginal areas of the river bed, would have been indirectly affected by daily changes in the water level. For example, samples obtained from marginal waters when the river level was stationary or falling could be expected to contain relatively large numbers of larvae from permanent colonies whereas samples obtained from newly colonized areas during periods of rising levels would contain relatively few larvae.

DISCUSSION, CONCLUSIONS AND FUTURE OUTLOOK

S. arcticum is widespread in Alberta and individuals typically breed in mountain-fed rivers and streams. Although individuals of a few other species of black fly also breed occasionally in these rivers, only those of *S. arcticum* are believed capable of developing in such large numbers that damaging outbreaks can occur. The precise factors affecting abundance and the subsequent development of outbreaks are not known.

Outbreaks in the Minburn area, presumably arising from the North Saskatchewan River downriver from Edmonton are rare. Only two brief damaging outbreaks have been recorded, one having occurred in late May of 1956 and the other in late May of 1961. Perhaps records of additional outbreaks of earlier years may eventually be discovered.

Outbreaks in the Athabasca area, arising from the Athabasca River, occur annually and generally last for several weeks at a time. Beginning as early as mid-June, they have lasted until about mid-September.

An abatement programme is presently being developed for the Athabasca area. Biological abatement does not seem feasible with our current state of knowledge of the species; thus chemical larviciding will be attempted. The development of a programme suitable for the Athabasca River requires a large number of field trials. Quantitative assessments of the

effects on black fly larvae and other aquatic organisms are difficult in this river because of the irregular and often large fluctuations in the water depth. The study should also include the accumulation of information on the durability, distribution and effects of not only the insecticide used but also of its break-down products. The major sources of black flies in the river should be accurately determined to allow best use of chemical larvicides, especially any with a short life. Possibly the entire river contributes to these outbreaks but in view of the lengthy flight range known for this species in Saskatchewan (Fredeen, 1958), the major sources may well be the extensive rapids downriver from Pelican Portage.

Another profitable area of research is the documentation of events associated with the development of outbreaks, eventually to permit, if possible, prediction of the time and severity of each impending outbreak. Such information would not only remove the elements of suspense that occur annually in this area but would also be useful in planning livestock management procedures and in planning the most economic utilization of larvicides.

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REFERENCES

Abdelnur, O. M. 1968. The biology of some black flies (Diptera: Simuliidae) of Alberta. Quaest. ent. 4: 113-174.

Brown, A., T. H. D. Griffitts, S. Erwin and L. Y. Dyrenforth. 1938. Arthus's phenomenon from mosquito bites. Southern Med. J. 31: 6, 590-596.

Cameron, A. E. 1922. The morphology and biology of a Canadian cattle-infesting black fly, *Simulium simile* Mall. Canada Dept. Agr. Tech. Bull. 5, n.s.

Canada Department of Energy, Mines and Resources. 1967. Surface water data, Alberta, 1965. Queen's Printer, Ottawa (i-xii) 241 pp.

Curtis, L. C. 1954. Observations on a black fly pest of cattle in British Columbia (Diptera: Simuliidae). Proc. ent. Soc. British Columbia 51: 3-6.

Fredeen, F. J. H. 1958. Black flies (Diptera: Simuliidae) of the agricultural areas of Manitoba, Saskatchewan and Alberta. Proc. 10th Int. Congr. Ent. Montreal, 1956: 3, 819-823.

Fredeen, F. J. H. 1963. Oviposition in relation to the accumulation of bloodthirsty black flies (*Simulium (Gnus) arcticum* Mall. (Diptera)) prior to a damaging outbreak. Nature (London) 200: 4910, 1024.

Fredeen, F. J. H., J. G. Rempel and A. P. Arnason. 1951. Egg-laying habits, overwintering stages, and life cycle of *Simulium arcticum* Mall. (Diptera: Simuliidae). Can. Ent. 83: 3, 73-76.

Fredeen, F. J. H., A. P. Arnason and B. Berck. 1953. Adsorption of DDT on suspended solids in river water and its role in black-fly control. Nature (London) 171:700.

Gudgel, E. F. and F. H. Grauer. 1954. Acute and chronic reactions to black fly bites (*Simulium* fly). A. M. A. Arch Derm. Syph. 70, 609-615.

Gurba, J. B. 1963. Personal communication.

Hearle, E. 1932. The black flies of British Columbia. Proc. ent. Soc. British Columbia. 29: 5-19.

Hutcheon, D. E. and V. S. Chivers-Wilson. 1953. The histaminic and anti-coagulant activity of extracts of the black fly. Rev. Can. Biol. 12: 1, 77-85.

Millar, J. L. and J. G. Rempel. 1944. Livestock losses in Saskatchewan due to black flies. Can. J. Comp. Med. Vet. Sci. 8: 334-337.

Rempel, J. G. and A. P. Arnason. 1947. An account of three successive outbreaks of the black fly, *Simulium arcticum,* a serious livestock pest in Saskatchewan. Sci. Agr. 27: 9, 428-445.

Rubzov, I. A. 1940. Fauna of the U. S. S. R. Diptera, Simuliidae. Acad. Sci. U. S. S. R. Moscow 6: 6, 1-532.

Stone, A. and H. A. Jamnback. 1955. The black flies of New York State (Diptera: Simuliidae). N. Y. St. Mus. Bull. 349, 1-144.

Strickland, E. H. 1938. An annotated list of the Diptera (Flies) of Alberta. Can. J. Res., D, 16: 175-219.

Twinn, C. R., B. Hocking, W. C. McDuffie and H. F. Cross. 1948. A preliminary account of the biting flies at Churchill, Manitoba. Can. J. Research (D) 26: 334-357.